ERIM
FORMERLY WILLOW RUN LABORATORIES, THE UNIVERSITY OF MICHIGAN

WHEAT PRODUCTIVITY ESTIMATES USING LANDSAT DATA

TYPE II PROGRESS REPORT

16 February 1977 - 15 May 1977

114800-35-L

NASA Contract No. NAS5-22389

Prepared by

Richard F. Nalepka - Principal Investigator

John Colwell - Co-Principal Investigator

Daniel P. Rice

Mr. G. R. Stonesifer, NASA Technical Officer/Code 902

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt Road
Greenbelt, Maryland 20771

20624

WHEAT PRODUCTIVITY ESTIMATES USING LANDSAT DATA

TYPE II PROGRESS REPORT

16 February 1977 - 15 May 1977

The following report serves as the eighth Type II Progress Report for Landsat Follow-on Investigation #2062L which is entitled "Wheat Productivity Estimates Using Landsat Data".

This investigation has several objectives, including the following:

1. To develop techniques and procedures for using Landsat data to estimate characteristics of wheat canopies which are correlated with potential wheat grain yield.

2. To demonstrate the usefulness of Landsat data for estimation of winter wheat yield:

   a. for irrigated and for non-irrigated test sites

   b. for two different years with varying weather conditions

1.0 PROBLEMS

No significant problems were encountered during this reporting period.

2.0 SIGNIFICANT RESULTS

The activities undertaken during this reporting period are still in progress, and as a result, there are no significant results to be reported at this time.

3.0 ACTIVITIES DURING THIS REPORTING PERIOD

During this reporting period, a large area demonstration of Landsat yield prediction capabilities using the Central Crop Reporting District of Kansas was initiated. We have also begun implementation of an agro-meteorological yield model, so that its performance can be compared with

that of a Landsat yield model. Further details concerning these activities are contained in the following sections.

4.0 LARGE AREA LANDSAT YIELD PREDICTION CAPABILITIES

The Central Crop Reporting District (CRD) of Kansas was chosen for a Landsat large area yield prediction demonstration. One reason this area was chosen is that, of the Kansas CRD's, it best satisfied the requirement for adequate "training" data. Information on individual field yield which is necessary in order to calibrate a Landsat wheat yield relation was available for three sites within the Central CRD.

It was decided that tests of the performance of the Landsat yield relation would be carried out using Landsat data from several individual sample segments, one in each of the 11 counties of the Central CRD. The rationale for this procedure is that the indicated yield on these sample segments, by appropriate aggregation, could approximate the average yield over the entire Central CRD.

4.1 DATA AVAILABILITY

It was decided to carry out the yield prediction test initially using early May 1976 Landsat data. It had previously been established that Landsat data gathered during early May (the time of heading for this region) was correlated with yield. During this time period, two of the three training sites had cloud-free Landsat data. The satellite passes which imaged these training sites occurred on dates separated by 1-2 days. This situation is considered acceptable, and perhaps desirable, for training data since the test data also was acquired on more than one day, and it was desired that the training data encompass the variability likely to be present in the test data.

While the selection of data for use reflects the optimum choice in terms of both data utility and data availability, there are some problems with data adequacy. Because of cloud cover and other limitations, only 7 of 11 counties within the Central CRD had test sites with useable Landsat data. The training and test data used is indicated in Table 1.

TABLE 1. LIST OF LANDSAT TRAINING AND TEST DATA

TRAINING SITES

Site (County)	Acquisition Date
Saline	4 May 1977
Saline	5 May 1977
Ellis	6 May 1977

TEST SITES

Russell	6 May 1977
Marion	4 May 1977
McPherson	4 May 1977
Rush	6 May 1977
Ellis	6 May 1977
Rice	4 May 1977
Saline	4 May 1977

4.2 DETERMINATION OF PHEOLOGICAL STAGE

As discussed in previous quarterly reports, it is important to apply Landsat yield relations to equivalent phenological stages, not necessarily to identical calendar dates. Therefore, an investigation of the comparability in phenologic stage for the training and test sites was conducted.

The growing degree days (GDD) were calculated using the definition found in "South Dakota Crop-Weather Summary", No. 1, 4 April 1977.

$$GDD = \frac{\text{Daily Max}\left|\text{Temperture } (\leq 86^{\circ}\text{ F}) + \text{Daily Min}\right|\text{Temperature } (\geq 50^{\circ}\text{ F})}{2} - 50^{\circ}\text{ F}$$

The maximum temperatures above 86°F were entered as 86° and minimum temperatures below 50°F were entered as 50°.

It was assumed there was no appreciable growth during January and February, so the calculations were started with 1 March 1976. The daily maximum and minimum temperatures were obtained from "Climatological Data" for Kansas, Volume 90, Numbers 3, 4, 5, and 6, from National Climatic Center, Asheville, N.C.

The temperatures were from the weather stations located in the counties of the Central Crop Reporting District, since daily temperatures from the actual Landsat sites were not available. Unfortunately, the weather stations for all counties were not near the Landsat sites in these counties. In Dickenson County the Landsat site and the weather station was fairly close together, while in Russell, Lincoln, and Barton they were relatively far apart. In Marion County the site is between two weather stations which reported very different temperature ranges. Therefore, care was taken when associating the GDD from a weather station with the sites in the same county.

The results of the GDD calculations, tabulated through April 16, May 4, May 13, and June 9 are found in Table 2.

The 15 sites can be loosely divided into three groups. The first seven from Table 2 are in Group 1, the coolest group. The middle group consists of the next four sites (8-11), and the last or warmest group is represented by the last four sites listed in the table. Based on these calculations and an examination of the map in Figure 1 no clear grouping was found either geographically or by date. The most northern weather station (Lincoln) and the most southern (Florence) are both in the warmest group. Similarly, it can be seen that the groups are well scattered throughout the district, with no group predominantly in any one area. The Marion County site is nearly equidistant from the Marion weather station, which is in the coolest group, and the Florence weather station, which is in the warmest group. In addition, there was

TABLE 2. RESULTS OF GROWING DEGREE DAY CALCULATIONS

	Weather Station	April 16	May 4	May 13	June 9
1	Russell	273.0	371.5	453.5	886.5
2	Kanopolis Dam	262.5	382.5	474.0	879.5
3	Wilson Lake	253.5	388.0	487.5	919.0
4	Hays	286.0	397.0	493.0	896.0
5	Salina	289.5	402.5	489.0	933.0
6	Marion	269.0	410.0	499.0	1,011.0
7	Abilene	298.5	428.0	526.0	960.0
8	Sterling	342.5	468.5	558.5	999.5
9	Herington	336.5	476.0	581.0	1,026.5
10	McPherson	340.5	480.0	578.0	1,032.5
11	Great Bend	358.0	473.0	579.0	1,038.5
12	Lincoln	367.5	520.0	621.5	1,081.5
12	Ellsworth	382.5	541.5	654.0	1,111.0
14	Bison	400.5	551.5	653.0	1,110.5
15	Florence	454.0	608.0	713.0	1,155.0
	μ	327.6	459.87	557.33	1,002.67
	σ	±58.23	±71.33	±77.51	±88.37

CENTRAL KANSAS CROP REPORTING DISTRICT

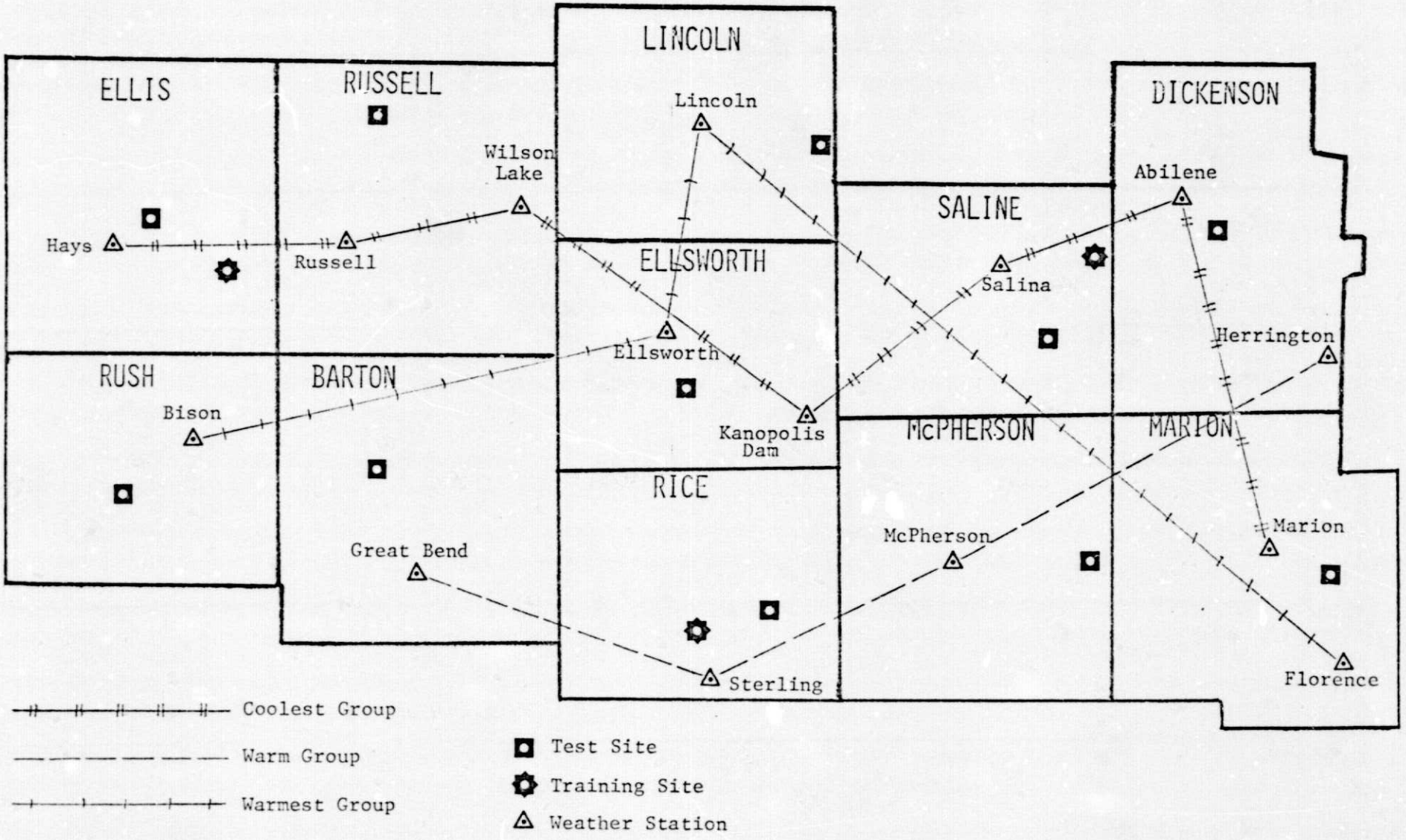

FIGURE 1. SITE LOCATIONS AND COMPARISON OF GROWING DEGREE DAYS

considerable overlap of the GDD numbers for the first three dates chosen.

4.3 LANDSAT YIELD PREDICTION TEST

Training and testing of Landsat yield prediction for the entire Central CRD is now in progress. It is now anticipated that the procedure will be implemented using a green measure transformation of the original (non-normalized) Landsat data, and also using a green measure transformation of XSTAR* normalized Landsat data.

5.0 AGROMETEOROLOGICAL YIELD MODEL

We have received documentation of the CCEA agrometeorological yield model from NASA/JSC. We are now collecting meteorological information required to implement the model. The model will be implemented for the Central CRD of Kansas, and the results will be compared with both the Landsat yield predictions and the Kansas Crop and Livestock Reporting Service (KCLRS) estimates of yield.

6.0 FUTURE PLANS

We will investigate the optimum way to carry out a yield estimate over an area as large as the Central CRD of Kansas. Among the factors included in the investigation are:

1. the importance and desirability of performing a haze normalization (like XSTAR) on the Landsat data,
2. the requirements for adequacy of training data.
3. the requirements for adequacy of test data.

We will compare Landsat results with CCEA and KCLRS estimates of yield.

We will also begin summarizing the results of this project in the final report.

* XSTAR is a haze correction algorithm developed recently under Contract NAS9-14988 with NASA, Johnson Space Center. It is described in quarterly report 122700-5-L, 17 September 1976, by R. Nalepka, et al, Task 2.

7.0 PUBLICATIONS

Significant results of our investigation were presented in a poster session at the Eleventh International Symposium on Remote Sensing of Environment by Richard Nalepka, John Colwell, and Dan Rice. The significant results have also been documented in a formal paper entitled, "Wheat Yield Forecasts Using Landsat Data", which will appear in the Proceedings of the symposium.